Serial No.: 09/828,564

Amendments to the Claims

1. (Currently amended) A thermosyphon for enhancing cooling of electronic systems, the thermosyphon receiving heat from a heat-dissipating component and comprising:

a central evaporator in contact with the heat-dissipating component;

a condenser in fluid communication with and extending around the periphery of the evaporator;

a liquid coolant partially filling the condenser and substantially ~~at least partially~~ filling the evaporator; and

means for cooling the condenser.

New matter

2. (Original) A thermosyphon as recited in claim 1, wherein the cooling means comprises cooling fins.

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3. (Original) A thermosyphon as recited in claim 2, wherein the cooling fins extend from the condenser.

4. (Withdrawn) A thermosyphon as recited in claim 1, wherein the cooling means comprises a fluid-cooled jacket adjacent to the condenser, the jacket defining a volume holding fluid that is cooler than the liquid coolant in the condenser, the fluid flowing through the jacket.

5. (Withdrawn) A thermosyphon as recited in claim 4, wherein the fluid-cooled jacket extends around the periphery of the condenser.

6. (Withdrawn) A thermosyphon as recited in claim 1, further comprising means for evacuating the thermosyphon.

7. (Original) A thermosyphon as recited in claim 1, further comprising a boiling enhancement structure disposed within the evaporator.

8. (Original) A thermosyphon as recited in claim 7, wherein the boiling enhancement structure comprises a plate having a first major surface and a second major surface, both surfaces having parallel grooves cut in them, the grooves in the first surface being perpendicular to the grooves in the second surface.

9. (Original) A thermosyphon as recited in claim 8, wherein the grooves in each surface are cut to a depth that is at least one half of the thickness of the boiling enhancement structure plate.

10. (Original) A thermosyphon as recited in claim 8, wherein the boiling enhancement structure material is selected from the group consisting of copper, diamond, and silicon.

11. (Original) A thermosyphon as recited in claim 7, wherein the boiling enhancement structure comprises open-celled porous foam.

12. (Original) A thermosyphon as recited in claim 1, wherein the central evaporator comprises:

a first plate having an interior major surface and an exterior major surface;

a second plate, generally parallel to, spaced from, and similar in planar dimension to the first plate, having an interior major surface and an exterior major surface, the interior major surface opposing the interior major surface of the first plate, with a central parallel plane passing through the space therebetween, the second plate exterior major surface in contact with at least a portion of the component and extending outside the limits of that portion of the component, wherein the interior major surfaces define an evaporator volume.

13. (Withdrawn) A thermosyphon as recited in claim 12, wherein the second plate further includes an opening that places the heat-dissipating component in direct contact with the liquid coolant, and the second plate sealingly engages the component.

14. (Original) A thermosyphon as recited in claim 12, wherein the second plate is formed with at least a portion of the heat-dissipating component from a single piece of material.

15. (Withdrawn) A thermosyphon as recited in claim 12, wherein the cooling means comprises a peripheral cooling plate extending from the condenser in a plane generally parallel to the central plane.

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16. (Withdrawn) A thermosyphon as recited in claim 15, further comprising cooling fins extending from the peripheral cooling plate in a direction away from the central plane.

17. (Original) A thermosyphon as recited in claim 12, wherein when the central plane is horizontal and the first plate is above the second plate, the liquid coolant fills the evaporator.

18. (Original) A thermosyphon as recited in claim 12, wherein through the range of angular orientation from when the central plane is horizontal and the first plate is above the second plate, to when the central plane is vertical, the evaporator is substantially full of liquid coolant.

19. (Original) A thermosyphon as recited in claim 12, wherein through the range of angular orientation from when the central plane is horizontal and the first plate is

above the second plate, to when the central plane is vertical, the evaporator is full of liquid coolant.

20. (Original) A thermosyphon as recited in claim 12, wherein at all orientations the evaporator is substantially full of liquid coolant.

21. (Original) A thermosyphon as recited in claim 20, wherein when the central plane is horizontal, the liquid coolant fills the evaporator both when the first plate is above the second plate and when the second plate is above the first plate.

22. (Original) A thermosyphon as recited in claim 12, wherein at all orientations the evaporator is full of liquid coolant.

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23. (Original) A thermosyphon as recited in claim 12, wherein the condenser comprises:

a first wall extending from each evaporator plate, the first wall having an interior surface, a proximate edge and a distal edge, the proximate edge sealingly joined to the periphery of the respective plate, and the first wall extending perpendicularly from the entire periphery of each plate in a direction away from the central plane for a substantially constant distance, whereby the distal edge is substantially parallel to the plates;

a second wall extending from each respective first wall, each second wall having an interior surface, a proximate edge and a distal edge, the proximate edge of each second wall sealingly joined to and extending perpendicularly from the entire distal edge of the adjoining first wall in a direction away from the evaporator volume; and

a third wall extending from each respective second wall, each third wall having an interior surface, a proximate edge and a distal edge, the proximate edge of each third wall sealingly joined to and extending perpendicularly from the

entire distal edge of the adjoining second wall such that the distal edges of the respective third walls abut and sealingly join at the central plane, whereby the interior surfaces of the first, second, and third walls define a condenser volume in fluid communication with the evaporator volume.

24. (currently amended) A thermosyphon as recited in claim 23 ~~20~~, wherein each plate and its respective walls are formed from a unitary piece of material.

25. (Original) A thermosyphon as recited in claim 23, wherein at all orientations the evaporator is substantially full of liquid coolant.

26. (Original) A thermosyphon as recited in claim 25, wherein the planar shapes of the evaporator and condenser peripheries are substantially rectangular.

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27. (Original) A thermosyphon as recited in claim 26, wherein the cross-sectional shape of the condenser along an edge of the evaporator and perpendicular to the central plane is generally rectangular, the condenser is generally symmetric about the central plane, and the dimensions of the evaporator and condenser approximately satisfy the following relationship, where H_B is the height of the condenser, H_E is the distance between the interior surface of the second plate and the interior surface of the first plate, L_B is the distance that the condenser extends from the periphery of the evaporator, perpendicular to the respective edge of the evaporator, L_E is the length of the evaporator along one edge, and W_E is the length of the evaporator along an edge perpendicular to the edge having length L_E:

$$H_B/H_E = (2L_B + L_E + W_E)/L_E.$$

28. (Original) A thermosyphon as recited in claim 27, wherein when the central plane is horizontal, the surface of the liquid coolant is approximately a distance of $(H_B + H_E)/2$ from the interior surface of the plate that is beneath the coolant.

29. (Original) A thermosyphon as recited in claim 25, wherein the planar shapes of the evaporator and condenser peripheries are substantially square.

30. (Original) A thermosyphon as recited in claim 29, wherein the cross-sectional shape of the condenser along an edge of the evaporator and perpendicular to the central plane is generally rectangular, the condenser is generally symmetric about the central plane, and the dimensions of the evaporator and condenser approximately satisfy the following relationship, where H_B is the height of the condenser, H_E is the distance between the interior surface of the second plate and the interior surface of the first plate, L_B is the distance that the condenser extends from the periphery of the evaporator, perpendicular to the respective edge of the evaporator, and L_E is the length of the evaporator along each edge:

$$H_B / H_E = 2(1 + L_B / L_E).$$

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31. (Original) A thermosyphon as recited in claim 30, wherein when the central plane is horizontal, within the condenser limits the surface of the liquid coolant is approximately a distance of $(H_B + H_E)/2$) from the interior surface of the plate that is beneath the coolant.

32. (Original) A thermosyphon as recited in claim 23, wherein at all orientations the evaporator is full of liquid coolant.

33. (Withdrawn) A thermosyphon as recited in claim 32, wherein the planar shapes of the evaporator and condenser peripheries are substantially circular.

34. (Withdrawn) A thermosyphon as recited in claim 33, wherein the cross-sectional shape of the condenser along the condenser radius and perpendicular to the central plane is generally rectangular, the condenser is generally symmetric about the

central plane, and the dimensions of the evaporator and condenser approximately satisfy the following relationships, where H_B is the height of the condenser, H_E is the distance between the interior surface of the second plate and the interior surface of the first plate, R_B is the radius of the condenser as measured from the center of the evaporator to the outer limit of the condenser, and R_E is the radius of the evaporator, and when the central plane is vertical, ϕ is the angle away from vertical of a line formed by the condenser radius when the outer endpoint of the condenser radius intersects the surface of the liquid coolant that fills the evaporator:

$$\phi = \frac{\pi}{2}\left(1-\left(\frac{R_E}{R_B}\right)^2\right)\left(1-\frac{H_E}{H_B}\right)+\frac{R_E}{R_B}\sqrt{1-\left(\frac{R_E}{R_B}\right)^2}$$

$$\phi = \cos^{-1}\left(\frac{R_E}{R_B}\right)$$

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35. (Withdrawn) A thermosyphon as recited in claim 34, wherein when the central plane is horizontal, on the surface of the liquid coolant is approximately a distance of $(H_B + H_E)/2$ from the interior surface of the plate that is beneath the coolant.

36. (Original) A thermosyphon as recited in claim 32, wherein the planar shapes of the evaporator and condenser peripheries are substantially square.

37. (Original) A thermosyphon as recited in claim 36, wherein the thermosyphon approximately satisfies the following relationships, where H_B is the height of the condenser, H_E is the distance between the interior surface of the second plate and the interior surface of the first plate, L_B is the distance that the condenser extends from the periphery of the evaporator, perpendicular to the respective edge of the evaporator, L_E is the length of the evaporator along each edge, θ is an angle between two parallel edges of the condenser planar limits and horizontal when the central plane is vertically oriented and surface of the coolant is at the uppermost point of the evaporator, θ^* is an angle between two parallel edges of the condenser planar limits and horizontal when

the central plane is vertically oriented and surface of the coolant is at the uppermost point of the evaporator and at the second highest corner of the condenser:

$$\theta^* = \tan^{-1}\left(\frac{L_B}{L_B + L_E}\right);$$

for $0 \le \theta \le \theta^*$:

$$\frac{H_B}{H_E} = \frac{2\left(1+\frac{L_B}{L_E}\right)\frac{L_B}{L_E}}{\frac{L_B}{L_E}+\left(\frac{1}{2}+\frac{L_B}{L_E}\right)\tan\theta}; \text{ and}$$

for $\theta^* \le \theta \le 45°$:

$$\frac{H_B}{H_E} = \frac{1+\frac{L_B}{L_E}}{1+\frac{1}{2}\left\{1-\frac{1}{2}(\tan\theta+\cot\theta)\right\}\frac{L_B}{L_E}}.$$

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38. (Original) A thermosyphon as recited in claim 37, wherein when the central plane is horizontal, within the condenser limits the surface of the liquid coolant is approximately a distance of $(H_B + H_E)/2$) from the interior surface of the plate that is beneath the coolant.

39. (Original) A thermosyphon for enhancing cooling of electronic systems, the thermosyphon receiving heat from a heat-dissipating component and comprising:

a central evaporator in contact with the heat-dissipating component;

a condenser in fluid communication with and extending around the periphery of the evaporator;

a liquid coolant partially filling the condenser and substantially filling the evaporator at all thermosyphon orientations; and

means for cooling the condenser,

wherein thermosyphon performance is substantially independent of thermosyphon orientation.

40. (Original) A thermosyphon as recited in claim 39, wherein the thermosyphon is generally planar and has a central plane passing therethrough, and the liquid coolant fills the evaporator at any orientation where the central plane is horizontal.

41. (Original) A cooling enhanced electronic component comprising:

a heat-dissipating electronic element;

a casing in which the element is disposed;

a thermosyphon adjacent to the casing, the thermosyphon comprising:

a central evaporator in contact with the heat-dissipating component;

a condenser in fluid communication with and extending around the periphery of the evaporator;

a liquid coolant partially filling the condenser and substantially filling the evaporator at all thermosyphon orientations;

means for cooling the condenser; and

wherein thermosyphon performance is substantially independent of thermosyphon orientation.

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42. (Original) A cooling-enhanced electronic component as recited in claim 41, wherein the thermosyphon is generally planar and has a central plane passing therethrough, and the liquid coolant fills the evaporator at any orientation where the central plane is horizontal.

43. (Currently Amended) A method of cooling a heat-dissipating electronic element, which comprises the steps of:

providing a thermosyphon, comprising:

a central evaporator;

a condenser in fluid communication with and extending around the periphery of the evaporator;

a liquid coolant partially filling the condenser and substantially ~~at least partially~~ filling the evaporator; and

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means for cooling the condenser; and

placing the evaporator in contact with the heat-dissipating element.

44. (Original) The method of claim 43, further comprising the step of providing a void in the evaporator to allow the coolant to directly contact the heat-dissipating element.